A sinusoidal sound wave has the speed \( v \) and wave length \( \lambda \). The sound wave travels in the positive \( x \)-direction and at \( (t=0, x=0) \) it has maximum upward displacement of \( A \).

Write the corresponding displacement \( y(x,t) \) and pressure \( p(x,t) \) wave equations in terms of \( (v, \lambda, A) \) describing the same wave. (Take the bulk modulus of the medium as \( B \).)

\[
y(x,t) = A \cos \left( \frac{2\pi}{\lambda} (x - vt) \right)
\]

\[
k = \frac{2\pi}{\lambda}, \quad \lambda f = v
\]

\[
\omega = 2\pi f = 2\pi \frac{v}{\lambda}
\]

(I) \[
y(x,t) = A \cos \left[ \frac{2\pi}{\lambda} (x - vt) \right] \quad \checkmark
\]

(II) \[
p(x,t) = -B \frac{\partial y}{\partial x} = -B A \left( -\sin \left[ \frac{2\pi}{\lambda} (x - vt) \right] \right) \cdot \frac{2\pi}{\lambda}
\]
\[
= \frac{2\pi}{\lambda} B A \sin \left[ \frac{2\pi}{\lambda} (x - vt) \right] \quad \checkmark
\]
The pressure in a traveling sound wave is given by the equation

\[ P = (1.5Pa)\sin \pi[(1.00m^{-1})x - (330s^{-1})t] \]

Find: a) the pressure amplitude, b) the frequency, c) the wavelength and d) the speed of the wave.

(a) \[ p(x,t) = B \alpha k \sin (kx - \omega t) \]

\[ B\alpha k = 1.5Pa \]

\[ A = 1.5Pa \]

\[ \frac{1.5}{\pi B} \]

\[ \approx \frac{1}{28} \]

(b) \[ \omega = 2\pi f = 330 \pi \]

\[ f = 115 \text{ Hz} \]

(c) \[ \lambda = \frac{2\pi}{k} \]

\[ k = \frac{\pi}{115} \]

\[ \lambda = 2 \text{ m} \]

(d) \[ v = \lambda f = 115.2 = 330 \text{ m/s} \]
Calculate the length of an organ pipe that is open at one end and closed at the other if its fundamental frequency is to be 9 times that of a pipe that is 7 m. long and open at both ends.

\[
\text{Open both ends: } \quad f_n = \frac{n \nu}{2L} = \frac{n \nu}{2 \cdot 7} \\
\text{One end open: } \quad f' = \frac{n \nu}{4L} = 9f_n = 9 \times \frac{n \nu}{14} = \frac{n \nu}{4L}
\]

\[
L = \frac{4 \nu}{4 \cdot 9} = \frac{14}{56} = \frac{7}{18} \text{ m}
\]
A railroad train is traveling at 30 m/s in still air. The frequency of the note emitted by the train whistle is 200 Hz. What frequency is heard by a passenger on a train moving in the opposite direction to the first at 18 m/s and moving away from the first? (Listener and source are moving away from each other!) The speed of sound is 340 m/s.

\[ f_L = \left( \frac{V + V_L}{V + V_S} \right) f_S \]

We choose + direction from listener to the source.

\[ V = 340 \text{ m/s} \]

\[ 30 \text{ m/s} \quad 18 \text{ m/s} \]

\[ f_L = \left( \frac{340 + 18}{340 + 30} \right) 200 \text{ Hz} \]

\[ = (0.87) (200) \text{ Hz} \]

\[ f_L < f_S \]
A railroad train is traveling at 30 m/s in still air. The frequency of the note emitted by the train whistle is 200 Hz. What frequency is heard by a passenger on a train moving in the opposite direction to the first at 18 m/s and approaching the first? (Listener and source are approaching each other!) The speed of sound is 340 m/s.

\[
\frac{f_L}{f_S} = \left( \frac{v_s + v_L}{v_s + v_S} \right) f_S
\]

\[
= \left( \frac{v_s + 18}{v_s - 30} \right) f_S = \left( \frac{340 + 18}{340 - 30} \right) 200 \text{ Hz.}
\]

\[f_L > f_S\]